DEPARTMENT OF ENERGY OPERATIONAL AND RESEARCH WEATHER PROGRAMS

For nearly 50 years, the Department of Energy (DOE) and its predecessors, the Atomic Energy Commission and the Energy Research and Development Administration, have established and supported meteorological operations and atmospheric research at the DOE field offices. The need for meteorological services began in 1944 with the development, fabrication, and testing of atomic weapons and the national security and safety issues associated with them. Meteorological program requirements were subsequently augmented by the passage of environmental protection legislation, which is enforced by the Environmental Protection Agency (EPA), and by several DOE Orders that specify requirements for meteorological services to protect public health and safety and the environment.

The Department of Energy (DOE) continues to address its mission areas of national security, science and technology, energy security, and environmental quality. Atmospheric science research and operations have been an integral part of DOE and its predecessor agencies since the cold war era. It is vital to understand the nature of the atmospheric domain with its various dynamic and chemical aspects of energy-related phenomena and how it interacts with the ocean and terrestrial domains. Today's global climate change debates and outcomes are relying on information collected through basic atmospheric science research programs that one day will reduce substantial uncertainties in these areas.

DOE coordinates programmatic activities throughout its various offices, such as Defense Programs (DP), Science (SC), Environmental Management (EM), and Energy Efficiency and Renewables (EE). Some of these program offices are responsible for the management of scientific research programs, such as the Atmospheric Release Advisory Capability (ARAC), Global Climate Change Research (GCCR), and various clean up activities at former production sites.

Meteorological services at DOE facilities range from cutting-edge basic research to providing daily operational support. Some examples of research and development are investigations of potential global climatic change, radiation and cloud studies, and studies of atmospheric boundary layer processes. Operational support programs include daily customized weather forecasting services, special project support, on-site meteorological monitoring programs, climatology services, and emergency response program support. Some DOE sites maintain 24-hour weather watches for severe weather conditions that could impact site operations, damage property, or threaten lives.

Several DOE field offices and their associated sites and facilities, such as Idaho National Engineering and Environmental Laboratory (Idaho Falls, Idaho), Oak Ridge Reservation (Oak Ridge, Tennessee), Nevada Test Site (Las Vegas, Nevada), Hanford (Richland, Washington), and Savannah River Site (Aiken, South Carolina) cover large areas. Several DOE sites are situated in areas of complex topography and heterogeneous surface characteristics, creating mesoscale conditions that locally influence on-site weather. For these reasons, and to protect public health and safety and environment, on-site meteorological monitoring programs have been and remain an essential part of DOE atmospheric science programs.

Some DOE sites enhance the spatial resolution of the National Weather Service (NWS) observing network by taking standard surface and upper-air observations. Many of these sites are in remote areas where weather observations would otherwise be limited. Weather observations taken at a few DOE field sites are entered into the database via the NWS meteorological data distribution and display system. This distribution and display system interconnects field offices and serves as the distribution system for NWS meteorological products that are centrally produced by the National Centers for Environmental Prediction (NCEP). Other DOE sites employ Automated Field Operations and Services (AFOS) units connected to the NWS AFOS network through NOAA Air Resources Laboratory (ARL)/Special Operations and Research Division (SORD), Las Vegas, Nevada.

An accidental release of radioactive or chemically toxic material into the atmosphere can have potentially serious health effects and environmental consequences. Meteorological processes play a key role in determining the fate of radioactive or toxic chemical pollutants released into the atmosphere. Consequently, a central theme within the DOE community has been to protect public health, safety, and the environment on and around DOE facilities by measuring and characterizing atmospheric processes.

In recognition of this need, DOE has established and supported on-site meteorological monitoring programs

since 1944 (i.e., Hanford site). Each meteorological program is primarily directed towards the support of emergency response programs and in the protection of the environment and safety and health of the on-site work force and the public. In addition, research on the modeling of the transport, dispersion, deposition, and resuspension of radioactive and toxic materials is undertaken to refine the models used in these endeavors. On-site weather forecasting services tailored specifically for the special operational and emergency management requirements at each DOE site provides necessary support to the safety and health of site personnel and the public.

Much of the research and most of the operational support has been provided by the atmospheric research programs at the six major field offices directly involved in national defense programs. Over the years, these programs have grown to address many environmental, safety, and health issues. Due to the complexity of these activities, it was recognized that efforts should be made to coordinate meteorological operations and research among the field offices to enhance cost effectiveness.

The following narrative highlights meteorological activities at fourteen DOE sites:

Nevada Test Site (NTS)

The NTS is managed and operated by the DOE Nevada Operations Office (DOE/NV). The NTS has been the Nations' underground nuclear weapons testing facility and is now used to support sub-critical experiments and other national defense missions of the United States. The NTS occupies 1,350 square miles of south central Nevada and is approximately 75 miles northwest of Las Vegas, Nevada. The topography of the NTS is complex with a system of dry lake beds and mountains. Elevations range from nearly 2,700 feet (ft) above mean sea level (MSL) to 7,600 ft MSL. The climate is arid.

Meteorological services are provided to DOE/NV by components of the Department of Commerce (DOC), National Oceanic and Atmospheric Administration (NOAA). The DOC has had a presence on the NTS for more than 45 years through various Interagency Agreements. During this time, NOAA personnel have built a solid technical reputation in meteorological operations and emergency response. Presently, NOAA support is provided by the Air Resources Laboratory/Special Operations and Research Division (ARL/SORD), recognized for its expertise in the transport, dispersion, and deposition of radioactive and toxic materials. SORD has developed a rapid emergency response capability for the unlikely occurrence of an accidental release of radioactive or hazardous material into the atmosphere.

Both basic and applied research is carried out on problems of mutual interest to DOE and to NOAA. Emphasis is on the maintenance of meteorological support to national defense projects and to the stewardship of nuclear weapons. These capabilities focus on those facets of meteorology having a direct bearing on the transport, dispersion, deposition (i.e., fallout), and resuspension of radioactive and/or toxic materials. Other research includes documentation and study of extreme precipitation events, desert thunderstorms, cloud-to-ground lightning, and environmental issues related to air quality and visibility.

ARL/SORD provides full meteorological support to all DOE/NV operations on and off the NTS. Meteorology plays a key role in environmental, safety, and health responsibilities of DOE/NV. The SORD staff is responsible for conducting a modern program in support of nuclear and non-nuclear projects authorized by DOE/NV. Furthermore, the mission of SORD involves technical support to the emergency preparedness and response activities of DOE/NV. SORD operates a comprehensive meteorological monitoring program for the NTS, and provides meteorological and climatology services required to support the DOE/NV and contractor programs at the NTS and elsewhere, as necessary. Personnel at SORD also consult with senior scientists and engineers at the DOE National Laboratories, National Aeronautical and Space Administration (NASA), private contractors, Desert Research Institute (DRI), United States Geological Services (USGS), United States Forest Services (USFS), and other NOAA laboratories.

The SORD meteorological monitoring network consists of thirty-one (31) 10m towers and two 30m towers. Wind direction and speed is measured at the 10m level on all the towers and temperature and relative humidity is sampled at the 2m level. Data from these towers are transmitted via microwave radio to a central processor that checks the data, creates data files, and archives the data every 15 minutes. The data files are accessed by microcomputer to create graphics products for operational use and for immediate display at 15-minute intervals.

SORD also operates two 915MHz vertical profilers on the NTS--one located in the middle of Yucca Flat and one at the Hazardous Materials Spill Center (HMSC) in Frenchman Flat near Mercury, Nevada. In addition, a NOAA full surface radiation (SURFRAD) budget station is operated and maintained at the Desert Rock Meteorological Observatory (DRA) located in the southern part of the NTS. Upper-air soundings are taken twice daily, at 00 and 12 Universal Time Coordinated (UTC) from the DRA facility. SORD also operates mobile upper-air sounding systems and mobile pilot balloon (PIBAL) equipment to support special projects requiring winds aloft data in real-time.

Large-scale meteorological data and National Center for Environmental Prediction (NCEP) weather forecast products are received via AFOS and AWIPS, or from University Center for Atmospheric Research (UCAR) and ARL-Silver Spring. SORD is the DOE node for distribution of NOAA/NCEP AFOS products. Other weather products supplied to DOE contractors, the National Laboratories (e.g., SNL, LANL, and LLNL), the NWS, and Nellis AFB include real-time cloud-to-ground lightning flash graphical products and local forecast products. SORD has also recently implemented the Regional Atmospheric Modeling System (RAMS) that can predict boundary layer air flow over complex terrain. RAMS accesses the NCEP predictive model outputs and is run at the University of Nevada at Las Vegas Supercomputer Center on a daily basis.

SORD provides meteorological monitoring support and project-specific weather forecast services to the Nuclear Emergency Search Team (NEST), the Federal Radiological Monitoring and Assessment Center (FRMAC), and the Accident Response Group (ARG) activities. Monitoring support includes surface and upper-air data collection and analysis. Weather forecast service entails maintaining a constant weather watch for conditions that might impact NEST/FRMAC/ARG operations and personnel, issuing site-specific mesoscale wind, stability, and weather forecasts, aviation weather support, and providing consultation to the On-Scene Commander and to National Laboratories personnel. SORD maintains a web site (*www.sord.nv.doe.gov*) that includes graphical products that display current meteorological conditions on the NTS, including data from SORD vertical profilers and climatological data.

Idaho National Engineering and Environmental Laboratory (INEEL)

INEEL is managed by the Idaho Operations Office and is on 890 square miles of rolling, arid terrain in southeastern Idaho at the foot of the Lost River and Lemhi mountain ranges. The primary mission of the INEEL for years has been nuclear reactor research with a focus on cleanup and environmental restoration. Meteorological services and supporting research are provided to INEEL via NOAA ARL Field Research Division (FRD). The Division, under administration from various agencies, has provided support to INEEL for over 50 years. Its current mission to DOE/ID is to support emergency response and operations with real-time meteorological data, climatological data, weather predictions, dispersion calculations, and consultation. ARL/FRD maintains other capabilities that are not funded directly by DOE. ARL/FRD designs, arranges, and conducts field studies as needed to evaluate the performance of transport and dispersion models over local, regional, and continental scales, and to obtain high quality databases for model improvement. An airborne geosciences program is also maintained to measure fluxes of carbon dioxide, water vapor, and other atmospheric constituents that affect climate. These interactions provide ARL/FRD staff with additional insights that aid in the understanding of local meteorological phenomena.

ARL/FRD operates a large meteorological monitoring network to characterize the meteorology and climatology of the INEEL site. The network consists of thirty-three meteorological towers that are deployed both on-site and off-site. The overall meteorological measurement program is designed to provide representative data for the INEEL to meet specific operational and potential emergency response situations. The network covers an area of approximately 15,000 square miles. Many of the towers are 15 meters (m) tall and provide wind speed and direction at 15m and air temperature at 2 and 15m. Fifteen of the 15m towers also provide relative humidity at 2m, precipitation, and global solar radiation, eleven provide barometric pressure. The other three towers range from 46 to 76m in height and are instrumented at multiple levels. The sensors at all stations are scanned every second and averaged or totaled over five minutes.

The data are subsequently retrieved into the data display and archive system at the ARL/FRD office through a radio repeater located at an elevation of 8,930 ft MSL. Continuous wind and temperature profiles are obtained from a 915MHz radar wind profiler and Radio Acoustic Sounding System (RASS). A Doppler SODAR supplements the wind profile at lower levels with higher resolution data. Meteorological data are quality-controlled through automated and manual processes.

INEEL meteorological monitoring and emergency response efforts are enhanced with the use of an ARL/FRD meteorological data display and visualization program known as INEELViz. This program has been widely deployed at 50 sites on and around the INEEL for access by federal, state, and Indian tribes via the Internet. Within INEELViz, meteorological data are displayed in real-time and overlaid on maps of the local area that include political and terrain features. In addition, the local MDIFF puff dispersion model can be accessed through the INEELViz front-end and the model output can be displayed as trajectories or concentration isopleths on the INEELViz display screen. The incorporation of RSAC dose conversions permits the user to also view real-time dose estimates from the model output. These features have become very useful enhancements to the INEEL emergency response capability.

Partnerships forged with DOE-ID, the State of Idaho INEEL Oversight Program, and the Shoshone-Bannock Indian Tribes have resulted in addition-

al methods of meteorological data dissemination. Meteorological and background nuclear radiation data from four public access sites on and surrounding the INEEL are displayed at nearby kiosks in real-time. Additional information on nuclear radiation and meteorological tutorials are presented at the kiosks. The data are also available on the Internet at *http://oversite.inel.gov*. ARL/FRD maintains its own web site at *www.noaa.inel.gov*.

Lawrence Livermore National Laboratory (LLNL)

The Lawrence Livermore National Laboratory (LLNL) is located in a valley in California's Coast Range Mountains about 25 miles east of Oakland. LLNL covers approximately 2 square miles and is operated by the University of California for the DOE Oakland Operations Office. Two groups are involved in the atmospheric sciences at LLNL: the Environmental Protection Department (EPD) and the Atmospheric Sciences Division (ASD).

EPD operates a 40m tower and supplies meteorological data for facility operations, regulatory compliance, and emergency response. Real-time and historical data are available via the World Wide Web (*http://www-metdat.llnl.gov/*).

Within the LLNL Earth and Environmental Sciences Directorate, ASD conducts research on climate and weather processes on local to global scales on the following issues:

(1) Understanding the transport, diffusion, deposition, transformation, and atmospheric effects of accidental releases or pollutants;

(2) Developing and testing models for improved representation of atmospheric processes on building, urban, regional, and global scales;

(3) Understanding the uptake and removal of carbon dioxide emitted through fossil fuel combustion by the biosphere and oceans so that the effects of future emissions may be accurately predicted;

(4) Understanding the role of pollutants from fossil fuel emissions in determining greenhouse gas and aerosol concentrations and climate forcing;

(5) Understanding and predicting the extent to which stratospheric ozone may decrease as a result of anthropogenic emissions;

(6) Understanding and quantifying the natural variability of the climate system; and,

(7) Understanding and quantifying interactions between the biosphere and climate. Some of these efforts stem from the need to be able to predict the regional to global environment and its changing nature over the next few decades, so that policy makers will have the information needed for the formulation of national energy policy.

LLNL ASD scientists contribute to two long-term DOE research programs--ARM and the Chemical Biological Non-proliferation Program (CBNP) as well as lead two other programs--PCMDI and ARAC. The Program for Climate Model Diagnosis and Inter-comparison (PCMDI) develops and distributes software tools to facilitate model diagnosis and inter-comparison, documents the features of models that are in use by the world climate community, and archives extensive collections of model output data. The Program also provides quality global observational products for application as model validation data (*http://www-pcmdi.llnl.gov/*).

Since 1979, LLNL has provided emergency response services via the Atmospheric Release Advisory Capability (ARAC) program. ARAC is a centralized federal resource responsible to DOE, the Department of Defense (DOD), and other federal agencies under the auspices of the Federal Radiological Emergency Response Plan (FRERP). The ARAC mission is to deliver realistic real-time graphical dose and exposure assessments to emergency decision-makers to assist in the protection of populations at risk for releases of radiological and other hazardous material to the atmosphere. ARAC supports all elements of the DOE Emergency Preparedness and Response Program, NEST, ARG, FRMAC, and the Radiological Assistance Program (RAP).

ARAC maintains and operates the National Atmospheric Release Advisory Center (NARAC). NARAC consists of automated continuous worldwide meteorological data acquisition, detailed worldwide terrain and geographic mapping databases, and a suite of three-dimensional, complex terrain, atmospheric dispersion models prepared to assess explosions, fires, vents, spills, or other releases of radiological or hazardous material. ARAC has an entirely new emergency response system with state-of-the-art, high-resolution, terrain-following, variable-gridded diagnostic meteorological and dispersion models including new user interfaces and extensive graphical displays. In addition, the system includes relocatable prognostic model that provides high-resolution 2-3 day forecasts in the region of interest.

NARAC provides a 24-hour on-call response, using redundant computer systems with uninterruptible power. NARAC provides on-site and off-site emergency response services to about 40 DOE and DOD facilities around the United States via a Site Workstation System linked to Livermore. Each Site Workstation also collects on-site meteorological data from one or more towers. The response time for the delivery of an initial ARAC assessment is less than 15 minutes for a computer-linked site and 45-90 minutes for a non-computer-linked site. ARAC has responded to over 80 real-world events and conducted thousands

of exercises with supported sites and agencies.

More information on the ARAC program can be located on the Internet (*http://www-ep.es.llnl.gov/www-ep/atm/ARAC/arac.html*) and an educational presentation of some past ARAC responses is located at *http://air.llnl.gov/*.

Oak Ridge Reservation (ORR)

The ORR is home to four DOE sites: Oak Ridge National Laboratory (ORNL), the Y-12 Plant, the East Tennessee Technology Park (ETTP, formerly K-25 Site), and the Oak Ridge Institute for Science and Education (ORISE). Managed by the Oak Ridge Operations Office (ORO), the ORR encompasses nearly 100 square miles of hilly and heavily vegetated terrain in eastern Tennessee.

Meteorological network systems which support day-to-day operations are managed and operated at the three main sites by Lockheed Martin Energy Systems, Lockheed Martin Energy Research and Bechtel Jacobs Company. These network systems provide data that support environmental management (permitting, facility siting and environmental impact assessment), facility safety (safety analyses), emergency management (hazards and consequence assessment), operations (work planning) and substantial research.

The meteorological data acquisition program at ETTP has two main towers. K-1209 is 60m high while K-1208 is 30m in height. In addition, two 10m battery-powered supplemental towers are still operating. A SODAR system, near the K-1209 tower also remains operational. Lastly, real-time output from an automatic lightning detection system that captures strike data from as far away as 100 nautical miles, a NEXRAD radar system, and *The Weather Channel* are available to each of the control rooms and emergency response facilities.

The Y-12 Plant has two meteorological towers (60m and 100m) located at the east and west ends of the site. ETTP and Y-12 Plant meteorological data is fed into the ORR Emergency Operations Center (EOC) and at emergency control centers for hazard assessment, consequence assessment, and protective action recommendations.

The data acquisition program at the ORNL consists of three (two 30m and one 100m) meteorological towers. Meteorological data is fed to an ORNL central computer system for analysis and dissemination.

The NOAA Air Resources Laboratory/Atmospheric Turbulence and Diffusion Division (ARL/ATDD) is located in Oak Ridge near the ORR. The primary mission of ATDD is atmospheric research. Substantial research programs at ATDD are undertaken with the assistance of staff from ORISE/Oak Ridge Associated Universities (ORAU) and scientists from other national laboratories and organizations in the United States and abroad. ARL/ATDD also works closely with the ORAU to enhance educational opportunities in atmospheric science.

ARL/ATDD research attention is focused on the physics of the lower atmosphere, with special emphasis on the processes contributing to atmospheric transport, dispersion, and air-surface exchange, and on the development and improvement of predictive capabilities using the results of this research. Many other projects are underway such as surface energy balance and CO_2 exchange studies and long-term studies of CO_2 exchange aimed at process-level understanding. Operationally, ARL/ATDD personnel provide meteorological consultation and supplemental data for air quality analyses, environmental reports, and hazard and consequence assessments. Local climatology data are routinely collected and distributed. Under NOAA funding, ARL/ATDD operates a regional network of 15 towers ranging from the Cumberland Mountains (middle Tennessee) to the Smoky Mountains on Tennessee's eastern border. Wind, temperature, and precipitation data are recovered every 15 minutes by telemetry and made available to users.

ARL/ATDD incorporates NWS forecast products into the high-resolution, regional, meteorological model (i.e., RAMS) to produce twice-daily 12-hour, 24-hour, and 36-hour predictions of surface winds for eastern Tennessee, and transport trajectory predictions for the ORR.

Sandia National Laboratory (SNL)

The DOE Kirtland Area Office manages SNL in Albuquerque, New Mexico, located between the Rio Grande Valley and Manzano Mountains. SNL covers approximately 80 square miles of flat to mountainous arid terrain. Meteorological Programs at SNL include both support and research activities.

Meteorological services and support are provided through the Environmental Operations Center (EOC) in the Laboratory Services Division (LSD). The mission is to provide meteorological support for various operations including: (1) emergency response, (2) environmental surveillance and characterization; and (3) regulatory compliance.

The monitoring network consists of six 10m and two 60m towers used to measure wind direction and speed, ambient temperature, and relative humidity. There are also three precipitation gauges, two barometric pressure sensors, and one solar radiation pyranometer in the network.

Key research activities are provided through the Energy and Critical Infrastructure Center in the Energy, Information, and Technology Division. SNL/NM scientists are involved in the Atmospheric Radiation Measurement (ARM) program and the Surface Heat Budget of

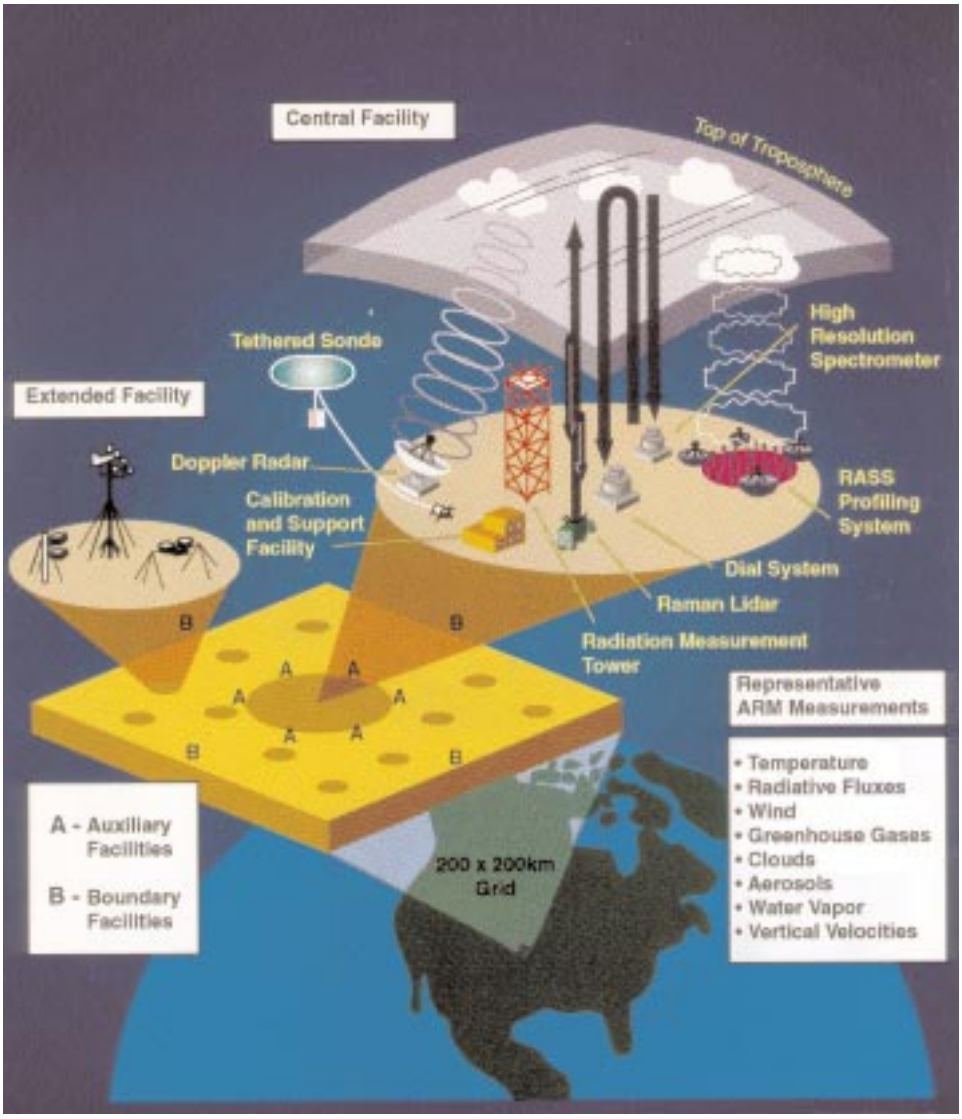

Figure 3-DOE-1. Program overview of DOE's Atmospheric Radiation Measurement (ARM) Program.

the Arctic Ocean (SHEBA). The ARM project is a combined measurement and modeling program (Figure 3-DOE-1). The goal is to gain a better understanding of clouds and their effect on atmospheric radiation, with the final goal of developing better climate models. The SHEBA program addresses the interaction of the surface energy balance, atmospheric radiation and clouds over the Arctic Ocean.

Los Alamos National Laboratory (LANL)

LANL is operated by the University of California under the responsibility of the Albuquerque Operations Office, and is spread across 43 square miles (112 km^2) of the Pajarito Plateau at the foot of the Jemez Mountains that extend up to around 900m above the plateau. LANL is about 30 miles northwest of Santa Fe in north central New Mexico. The Pajarito Plateau slopes to the east-southeast, dropping 400m across the Laboratory, with canyons and mesas running along the slope of the plateau. The broad Rio Grande Valley lies to the east of the laboratory. Los Alamos has a semi-arid, temperate, mountain climate.

The operational meteorological program at Los Alamos operates a network of six towers (ranging in height from 23m to 92m), a mono-static Doppler SODAR, and three supplemental precipitation stations. Data from four instrumented meteorological towers that are located on the Pajarito plateau drives a diagnostic wind field for the program's plume modeling capability. A fifth tower is located in Los Alamos Canyon to give information on the larger canyons in the area, and a sixth tower is located on top of Pajarito Mountain to measure ambient conditions. The SODAR gives information on winds up to the level of the Pajarito Mountain tower.

More than 100 instruments, consisting of over 20 different types of sensors, are used to collect data throughout the network. Variables measured by the program can be grouped into the categories of wind, SODAR-derived wind, atmospheric state, precipitation-related, radiative fluxes, eddy heat fluxes, subsurface measurements, and fuel moisture. Data collected by the network are checked for quality before its archival, and raw data and real-time displays of graphs and tables are made available via the Internet.

The LANL Air Quality Group provides regulatory and environmental surveillance leadership and services to meet LANL air quality obligations and public assurance needs. The group develops and implements programs to ensure and address institutional compliance with State and Federal laws related to air quality regulations, DOE orders for emergency management, air quality surveillance, dose assessment activities, and community concerns related to air quality issues. The group takes a proactive approach to managing air emissions by providing continuous air monitoring and measurement of external penetrating radiation on-site and off-site. The group also coordinates LANL activities to ensure full compliance with air emission regulations, providing monitoring and modeling for emergency response, and assisting operating groups in developing and implementing new methods and systems to reduce emissions to as low as reasonably achievable. The

monitoring capabilities of the Air Quality Group are supplemented by the field team of the Atmospheric and Climate Sciences Group, that operates various sensor systems including a unique Raman lidar system to obtain images of atmospheric water vapor distributions.

Research within the LANL Atmospheric and Climate Sciences Group supports DOE missions in both the defense and civilian sectors, such as work in the propagation of very-low-frequency sound ("infra-sound") waves. Modeling studies contributed to understanding of propagation and, in particular, sources of infrasound. Just as it is possible to infer earthquake epicenters from seismic wave observations, infra-sound sources can be inferred from atmospheric observations. This work is an important component of monitoring compliance with the proposed Comprehensive Test Ban Treaty (CTBT). The CTBT work involves a number of organizations within DOE and DOD community, including interactions with other DOE laboratories within the CTBT Research and Development program.

Operational issues involve close work with the Air Force Technical Applications Center (AFTAC) at Patrick AFB, Florida, the DOD organization that handles monitoring systems. In addition, several active international collaborations with other infra-sound researchers are ongoing.

The Meteorology Team within the Atmospheric and Climate Sciences Group at Los Alamos National Laboratory conducts analysis and modeling on microscale to mesoscale atmospheric flows and phenomena. In support of the DOE Chemical and Biological Non-proliferation Program, a model for High Resolution and Strong Gradient (HIGRAD) applications is being used to study the effects of radiative heating and shading around groups of buildings. The objective of this study is to determine how these processes may influence the transport of agents within the urban environment. On larger scales, the team is examining the influence of flow merger and urban roughness on the vertical transport and mixing of pollutants with the Regional Atmospheric Modeling System (RAMS) for several western United States valleys and basins. This project is in support of the DOE Environmental Meteorology Program and for the Environmental Protection Agency (EPA). As part of the LANL initiative in Coupled Environmental Modeling, researchers within the Meteorology Team are developing a physics-based fire behavior model (FIRETEC) and coupling this model to the HIGRAD atmospheric dynamics code to examine the details of the interaction between local winds and the intense heat generated by wildfires. Also as part of this initiative, a land surface model is being coupled that includes hydrologic processes (i.e., SPLASH) to the RAMS mesoscale model for multi-seasonal simulations of the water resources of the upper Rio Grande Basin.

Meteorology Team members are also working on the LANL Urban Security project, which is linking physical and urban growth models to address the needs of cities. In this framework, we are using the RAMS model to provide meteorological fields for use by air chemistry, urban runoff, and other models. The Meteorology Team within the Atmospheric and Climate Sciences Group conducts analysis and modeling on microscale to mesoscale.

On global scales, research within the LANL meteorological community involves the study of climate change and variability. A major project is the development of a global coupled ocean-atmosphere model sponsored by the DOE Climate Change Prediction Program. The global model being developed consists of a Los Alamos global ocean Global Climate Models (GCMs) Parallel Ocean Program (POP), the Los Alamos sea-ice model (CICE), the NCAR Community Climate Model (CCM3), and a "flux coupler" to link the media consistently. The two GCM's and the CICE model exchange heat, momentum, and water mass across the air-sea boundary. A ten-year synchronized simulation revealed the synoptic weather events, seasonal cycles and inter-annual variations.

Observations related to understanding global climate are the focus of the Tropical Western Pacific (TWP) Program Office LANL, an element of the DOE ARM Program. The TWP Program Office is responsible for the development and operation of the TWP CART locale, a large expanse of tropical ocean and maritime continent lying roughly between 10° S and 10° N latitude and from 135° E to 150° W longitude. The maritime continent area is largely in the southwest and the open ocean area in the northeast of the locale. The local climate is characterized by warm sea surface temperatures, deep and frequent atmospheric convection, high rain rates, strong coupling between the atmosphere and ocean, and substantial variability associated with El Niño Southern Oscillation (ENSO) phenomenon.

Scientific questions that need to be addressed in the TWP can be grouped under three main headings: (1) radiation budget and cloud forcing, (2) water and energy budgets; and (3) ocean-atmosphere interactions.

The program supports a variety of operations at LANL. The primary client of the program is the Emergency Management Group, for which the program provides a plume modeling capability. Other clients use the program's data for such activities as operations and planning, hazard and accident analyses, environmental studies, support for experiments, compliance, and documentation.

Pantex Plant

The Pantex Plant covers 15,977 acres and is located 27 kilometers (17 miles) northeast of Amarillo, Texas, in Carson County. The Plant was a World War II munitions factory and was converted to a nuclear weapons assembly facility in 1951. Today, it is the nation's only assembly/disassembly facility supporting the nuclear weapons arsenal. Pantex Plant is a government-owned, contractor-operated facility. DOE oversees operation of Pantex Plant through the Amarillo Area Office, which reports to the Albuquerque Operations Office. Mason and Hanger Corporation have been the operating contractor since 1956.

The Waste and Environmental Management Department (WEMD) of the Applied Technology Division is tasked with the quality assurance program for the meteorological data captured by the one on-site two-level tower located in the northeast corner of the Plant site. The data from this tower (10m and 60m) are collected and used by the DOE ARAC site work station, located in the Plant EOC. These data are collected and archived as 15-minute averages plus maximum and minimum values for each 15-minute period. They are primarily used for input to the ARAC emergency response models that could be used for off-normal events involving radionuclides. Annual dispersion model calculations, of off site radiation doses from on site sources, required by 40 CFR 61, Subpart H, *National Emission Standards for Hazardous Air Pollutants* (NESHAP), are accomplished by WEMD using the EPA approved CAP88PC model and the Pantex meteorological tower data processed into the STAR format. WEMD also maintains the Pantex Plant climatology database.

Meteorological tower data is also used by the Risk Management Department for plume dispersion modeling applied to the Plutonium Dispersal Consequence Analysis for the Basis for Interim Operations (BIO) validation and upgrade reports, other operations directives, and other safety analyses.

Routine preventive maintenance on the meteorological instruments as well as calibration and certification are done semi-annually by the United States Bureau of Land Management (BLM). The BLM maintenance depot at Boise, Idaho performs similar work for the United States Forest Service's own meteorological towers instruments. This work is done under a contract administered by Battelle-Pantex. Emergency repairs and replacement of sensors are also handled by the BLM Idaho depot. Temperature and wind sensors are replaced semi-annually with calibrated and certified sensors. The barometer is replaced annually. During the semi-annual preventive maintenance visits, all of the other instruments are replaced by the BLM technician with rebuilt/refurbished, calibrated equipment, from the Idaho depot. The maintenance check also includes the telephone line, modem, and backup power supply.

No special meteorological activities are planned at Pantex for FY 2000; however, efforts are underway to display the meteorological tower data on the Pantex Plant Intranet for use by Plant personnel. There are no current or projected supporting meteorological research activities planned at Pantex.

Savannah River Site (SRS)

The SRS is under the responsibility of the Savannah River Operations Office (SR) and operated by the Westinghouse Savannah River Company. SRS is located in southwestern South Carolina, along the banks of the Savannah River. The SRS covers an area of approximately 300 square miles. It is heavily vegetated with evergreen trees and contains many streams, a swamp, and a 2,700-acre reservoir built as a cooling pond for the plant reactors. The topography of SRS is characterized by gently rolling forested hills with an adjacent flood plain near the Savannah River. The climate at SRS is typical of the southeastern United States with long, hot and humid summers and short mild winters.

The Atmospheric Technologies Group (ATG) of the Savannah River Technology Center (SRTC) developed the SRS meteorological monitoring and modeling program in the early 1970's. This program supports the SRS operations in the areas of emergency response consequence assessment, radiological and non-radiological air quality calculations for regulatory compliance, safety analyses, environmental impacts, engineering studies, environmental research and non-proliferation activities.

Meteorological activities include daily weather forecasting services in support of operations at SRS, with particular emphasis on severe weather impacts. Local meteorological data are obtained from a network of eight 200-foot meteorological observing towers located near the major production sites. The instrumentation on these towers includes sensitive bi-directional vanes (i.e., bi-vanes), cup anemometers, resistance thermometers and lithium chloride humidity sensors. Additional meteorological instrumentation is located at the Central Climatology Facility located near the geographical center of the site to measure precipitation, evaporation, barometric pressure, soil temperature, solar and long wave radiation. Central Climatology includes a 200-foot tower instrumented at four levels. A network of twelve additional rain gauges (that are read daily) is located within SRS. Additional local upper-air data are collected from three acoustic Doppler radars, an airsonde system, and a tethersonde system. Portable towers are used for case studies.

A collaborative agreement with surrounding counties involves assisting them to install and operate several local meteorological towers at nearby

chemical plants. Data from these towers are being integrated into the SRS meteorological archiving and display system the Weather Information and Display System (WINDS).

The WINDS is the primary consequence assessment system for atmospheric and hydrologic releases from SRS operations. A suite of atmospheric models linked to real-time site wide atmospheric monitoring provides transport, dispersion and consequence calculations for emergency response.

The WIND system underwent a complete re-engineering to improve the computer system reliability, performance and serviceability. The re-engineering involved distributing the data processing and utilizing new data acquisition hardware and relational data base software. New workstation clustering for data management and PC/NT user workstations for local model operation and graphical user interfacing for displays were added.

An advanced non-hydrostatic, three-dimensional, prognostic atmospheric model is run twice daily on the SRTC's CRAY computer separate domains: (1) the Central Savannah River Area (CSRA), (2) kilometer grid resolution); and (3) the area encompassing South Carolina and Georgia (20 kilometer resolution).

The CSRA model provides forecasts with a minimum of six hours useable forecast fields. The Georgia-South Carolina model run provides forecasts with a minimum of 24 hours useable forecast fields. These forecast fields are integrated into the WIND system consequence assessment models. Additional model runs are conducted on an expanded domain to include the entire southeastern United States on an *ad hoc* basis when the SRS is threatened by hurricanes.

An aqueous model is also resident on WINDS and linked to real-time stream flow monitors operated by the USGS. This model enables consequence assessments for emergency response to site streams and the Savannah River.

Regional, national, and international meteorological data are received from a commercial weather data provider via satellite in real-time. Weather workstations provide surface and upper observations, analyzed and forecast weather parameter fields from the NWS and the European Modeling Center. These data are input into an advanced, three dimensional, prognostic, atmospheric modeling system for applications locally in the southeastern United States and globally. Satellite and Doppler radar data are also available in near real-time.

Rocky Flats Environmental Technology Site (RFETS)

The RFETS is managed by the Rocky Flats Operations Office and is located approximately 16 miles northwest of downtown Denver, Colorado. One of the smaller DOE sites, the facility occupies a 10 square mile area along the foothills of the Rocky Mountain Front Range.

A 61m meteorological tower at the west-end of the site continuously monitors meteorological conditions at surface, 10, 25, and 60m above ground level. A backup, 10m tower is located nearby to ensure 100 percent data recovery. The data are analyzed, quality assured, and assembled into data sets for use in atmospheric modeling, climatology, and other analyses at the site. Data from the 61 and 10m towers are also transmitted back to the main site every 15 minutes by telemetry for use in emergency response modeling. The Regional Atmospheric Response Center (RARC) conducts meteorological activities associated with emergency preparedness and response at the site. An upper air remote sensing Sound Detection and Ranging/Radio Acoustic Sounding System (SODAR/RASS) continuously monitors winds, temperatures, and atmospheric stability above RFETS.

Through a cooperative agreement with the Colorado Department of Public Health and Environment, meteorological data are transmitted to the site from five surface meteorological stations by telemetry that form a ring around the site perimeter. Another cooperative agreement with NOAA provides near real-time data from multiple monitoring sites throughout the Denver metropolitan area. These data are all received, quality assured, and combined into a 3-dimensional observation set for emergency response modeling every 15 minutes, 24 hours per day.

The RARC provides 24-hour consequence assessment support for any unplanned radiological or chemical releases from the site. The Center responds with customized weather forecasts, plume projections, and dose modeling results that lead to event classifications and protective actions for on-site and off-site populations. RARC also conducts specialized consequence assessments in support of emergency preparedness, hazard assessments, and risk assessments for RFETS. Weather forecasts are provided for severe weather events, such as winter storms, windstorms, and severe thunderstorms.

A customized modeling system has been developed and implemented at RFETS to predict the path and impacts from any radiological emergency at the site. Called the Computer-Assisted Protective Action Recommendation System (CAPARS), the new capability addresses the need for fast, accurate plume predictions in a complex atmosphere.

CAPARS provides a variety of plume, weather, hazard, and related products with the accuracy and speed needed for response to an emergency at RFETS. Eleven integrated major subsystems form the overall CAPARS capability. The State of Colorado has formally accepted the CAPARS modeling system for emergency response and planning applications at RFETS. A specialized planning version of the

CAPARS system has been developed, implemented, and applied for emergency planning at the RFETS. Called the TRAC Risk Assessment/Hazards Assessment Model, the capability is designed to support hazards and risk assessments for RFETS and to form the basis for an evaluation of the size and shape of the Emergency Planning Zone (EPZ) surrounding RFETS.

Hanford Site

For more than 55 years, meteorological services have been provided to the Richland Operations Office and the Hanford Site. For the last 33 years, this program has been managed by the Battelle Pacific Northwest National Laboratory) (PNNL). Not only has operational support been provided, but also supporting research into atmospheric processes has been a key part of the PNNL support to DOE Richland. The facility covers 560 square miles within the arid and sparsely vegetated Columbia River basin in southeastern Washington.

Global Climate Research Program focuses on the study of basic geophysical processes and on the development of databases that are critical for understanding global and regional climate change. The ARM program is designed to characterize empirically the radiative processes in the atmosphere with high spatial, temporal, and spectral resolution and accuracy at three climatically distinct sites--the Southern Great Plains of Oklahoma; the tropical Western Pacific just off the northern part of Papua, New Guinea; and the north slope of Barrows, Alaska. In addition, carbon dioxide emissions research is aimed at providing a scientific basis for forecasting future emissions of carbon dioxide and other important gases of radiative importance.

The PNNL Meteorological and Climatological Services Project (MSCP) office provides meteorological monitoring and operational support. The monitoring system consists of an array of twenty-six 10m towers, three 60m towers and one 125m tower instrumented with temperature and wind direction and speed sensors. Atmospheric pressure and precipitation data are also collected. Data from this network are transmitted via UHF radio to a computer that decodes the data and plots graphics products for immediate display and use by Hanford Meteorological Station personnel. Other meteorological data are received via the NWS/DOE AFOS network. Meteorological services include emergency response functions, weather forecasting for on-site operations and special projects, and climatological support. MSCP support to the Hanford site includes: (1) extensive data acquisition via a site-wide meteorological monitoring network; (2) weather forecasting services 24-hours/day (Monday through Friday), and 8-hours/day on weekends and holidays; (3) hourly surface observations, and 6-hourly synoptic observations; and, (4) monthly and annual climatological data summaries, plus meteorological input to annual environmental reports.

Brookhaven National Laboratory (BNL)

The BNL, under the responsibility of the Brookhaven Area Office, has been active in both operational meteorology and atmospheric sciences for the past 50 years. BNL is now managed by the Brookhaven Science Associates which is a joint venture by Battelle Memorial Institute Incorporated, The Research Foundation of the State University of New York at Stony Brook, and six other core university partners. Meteorological operations and research cover a wide range of programs encompassing interpretive and theoretical studies. BNL is located near the geographical center of Long Island, New York. Long Island is glacial in origin and, as a result, has sandy soil, mostly gentle undulating contours, and a single water aquifer for the entire island. Elevations vary between 20m and 35m. The BNL site is rectangular and approximately 5,200 acres in area. Winds are predominantly southwesterly, and plume dispersion studies show that it is essential to monitor winds well beyond laboratory borders. The NWS New York City Weather Forecast Office is located at BNL. This office has an umbrella of coverage that includes an estimated population of 1 million. Nearby, in Bohemia, is the NWS Eastern Regional Headquarters that administers a 12-state region.

The mesoscale meteorological measurements necessary for emergency response are the responsibility of the Meteorological Services Group, a support group under the Department of Applied Science, Environmental Biology and Instrumentation Division (EBID).

The Meteorological Services Group maintains two meteorological towers, 10m and 88m, and an instrument shelter. By integrating redundant pairs of standard, approved meteorological sensors throughout the system, an overall data availability of better than 99 percent is achieved. The real-time data are merged into the laboratory emergency response network. A database of 50 years (in digital format since 1960), one of the longest continuous meteorological time series in the United States, is archived and is available. A real-time monitoring network with worldwide web access covers the east-end of Long Island. Coastal weather stations at Smith Point and Orient Point transmit data each minute. Pollution-monitoring data buoys are added during field programs.

The Meteorological Services Group provides a locally tuned forecast twice daily during normal working hours. Weather forecasts and data are available by telephone or the Internet (*www.weather.bnl.gov*). During severe weather events updates are given every 3 hours and, in the case of a hazardous material or radiological release, a

Figure 3-DOE-2. Battelle operates the Gulfstream-1 as a research facility under contract with the DOE's Atmospheric Chemistry Program.

member of the Meteorological Services Group will assist the emergency coordinator with regular forecasts and information on local wind fields and gustiness. Areas of meteorological research include:

(1) instrumentation development for field studies of atmospheric constituents, air-sea interaction, and laboratory experiments;
(2) gaseous tracer studies of atmospheric transport and dispersion;
(3) aerosol formation and behavior;
(4) atmospheric pollution studies;
(5) modeling of atmospheric chemical reactions;
(6) acid rain studies both in the field and in the laboratory;
(7) theoretical and observational studies of radiative transfer and fluxes; and,
(8) analysis of data and development of parameterizations relevant to global climate change.

The Atmospheric Radiation Measurement (ARM) Program provides the stimulus for a wide range of climate-related studies. The ARM ocean monitoring program is developing instrumentation and a broad ship- and buoy-based observational network in the tropical western Pacific Ocean. The Atmospheric Chemistry Program (ACP) provides the Atmospheric Chemistry Division's concern with aerosol sources, transport, and fate in the global atmosphere and the overall, and little understood, impact of aerosols on global climate dynamics. The ARM External Data Center is the center for collection, archival, and dissemination of all climate-related data sets for the ARM program (Figure 3-DOE-2)

An exciting new effort in radar meteorology focuses on algorithms for cloud detection and cloud mapping using both the WSR-88D radar network and research radar. BNL is a site in the NASA Solar Irradiance Network and continuous short wave absorption measurements are made here. In a related NASA study, oceanic aerosol optical depths are measured and used to validate absorption algorithms in the SeaWiFS ocean color program.

The Optical Remote Sensing group within the Department of Advanced Technology is presently modifying one of its Raman lidar systems for vertical profiling of carbon dioxide. The Raman lidar instrument is a self-calibrating sensor that means that data from a variety of locations in the world can be compared. With the incorporation of a large (1.25m) antenna and advanced filters and detectors, a vertical profile of CO_2 concentration with a precision of 1 part per million (ppm) (Note: atmospheric mean = 370 ppm) and maximum height of 2-3km can be produced routinely. These profiles will support model development and validation. Importantly, comparison of CO_2 concentrations collected throughout the world and over time will prove invaluable in confirming adherence to the Kyoto protocols.

Waste Isolation Pilot Plant (WIPP)

The Waste Isolation Pilot Plant (WIPP) is operated by Westinghouse Electric Company's Waste Isolation Division for the DOE Carlsbad Area Office. A cornerstone of the DOE's national clean-up strategy, the WIPP is designed to permanently dispose of transuranic radioactive waste generated by defense-related activities in the Salado salt formation 2,150 ft beneath the surface. WIPP is located in Eddy County in southeastern New Mexico, 26 miles east of Carlsbad, and occupies 16 square miles of a region know as Los Medanos. Geographically, the region is regarded as a relatively flat, sparsely inhabited plateau with little surface water.

The WIPP Environmental Monitoring (EM) Section performs meteorological monitoring as part of the Non-radiological Environmental Monitoring Program. The primary meteorological station provides measurement of wind direction and speed, temperature at 2, 10, and 50m, as well as ground level measurements of barometric pressure, relative humidity, precipitation, and solar radiation. The main function of the station is to generate data for operational support, emergency response and regulatory dispersion modeling applications. Parameters are monitored continuously and the data are stored in the Central Monitoring System, a computerized system including automated parameter checks, real-time displays in the Central Monitoring Room, and data archiving. Meteorological data are compiled and distributed to stakeholders, including the NOAA NWS, on a monthly basis.

In addition to the primary meteorological station, the Far Field Station serves as a secondary meteorological station and measures wind direction and speed at 10 meters as well as temperature, barometric pressure at ground level. System upgrades are currently being considered for this station.

WIPP also, under a cooperative agreement with the NWS, maintains a Cooperative Weather Observing Station at the Far Field Station. Data from this station are compiled monthly and the Record of Climatological Observations form is submitted to the Weather Forecast Office in Midland, Texas. Under the same cooperative agreement, the Midland office is given

access to real-time data from the primary meteorological station.

Weldon Springs Site Remedial Action Project (WSSRAP)

Various facilities at Weldon Springs in St. Charles County, Missouri were no longer needed, and a Remedial Action Plan (RAP) was developed to restore the site to its environmental baseline. This activity is being coordinated under the Weldon Springs Site Remedial Action Plan (WSSRAP), under the management of Jacobs Engineering Company.

Fourteen interim response actions were developed and approved by WSSRAP. Interim response actions are activities that will not change the ultimate disposal method but will mitigate or eliminate conditions that pose immediate or potential threats to worker safety, public health, or the environment. Some of the interim actions taken were removal of exposed friable asbestos, overhead piping, polychlorinated biphenyl (PCB) electrical equipment, power poles and wires, demolition of all buildings, isolation and capping of Ash Pond, and capping of other highly contaminated areas. Additional areas to undergo remediation are scheduled through 2001, which is the projected date for completion of all remediation activities.

Within the Environmental Monitoring Plan is a meteorological monitoring program, which has a monitoring station. The meteorological monitoring station is located along the eastern perimeter of the chemical plant site more than 400 ft from the nearest building and is considered representative of all areas undergoing remediation. The WSSRAP meteorological station continuously records wind speed and wind direction at 10m above ground level, as well as horizontal wind fluctuation, barometric pressure, relative humidity, incoming solar radiation, and precipitation intensity. The sensors are designed for and calibrated within measurement ranges encompassing all credible meteorological conditions at the site.

The meteorological monitoring program include numerous program functions at WSSRAP:

(1) Meteorological information to support emergency response activities in the event of an unscheduled chemical or radiological release;

(2) Information for atmospheric dispersion modeling to provide an environmental safety and health contribution to engineering design of site facilities;

(3) Rainfall, temperature, and wind speed data to support wetland and lake ecological studies and for support of foliar vegetation absorption analysis;

(4) Precipitation data to support the correlation of aquifer level fluctuations in the quarry and Femme Osage Slough;

(5) Environmental reporting including the annual Weldon Spring Site Environmental Report and the Effluent Information System/On-Site Discharge Information System Report;

(6) Wind speed data needed for compliance with Occupational Safety and Health Administration (OSHA) construction management activities;

(7) Precipitation data to support the National Pollutant Discharge Elimination System storm water permit application; and,

(8) Temperature and relative humidity data to support environmental safety and health field activities during periods of extreme heat and cold.

Yucca Mountain Project Office (YMPO)

An extensive air quality and meteorology monitoring program has been established at YMPO that is managed and operated by Science Applications International Corporation (SAIC), Summerlin, Nevada.

This program supports the site characterization and licensing of the site that DOE Office of Civilian Waste of Radioactive Materials has preliminarily selected for the disposal of high-level radioactive waste.

DOE Meteorological Coordinating Council (DMCC)

Based on a need to facilitate more coordination and cooperation among the meteorological activities at the DOE field offices, the DMCC (the Council) was established in December 1994. The mission of the Council is to coordinate meteorological support and research to meet DOE objectives. The objectives of the council are to: (1) promote cost-effective support for all DOE facilities; (2) plan for future needs, requirements, and missions; (3) advocate awareness of atmospheric science applications and benefits to DOE; and, (4) advocate the use of common methods, procedures, and standards.

Council oversight is provided by a steering committee consisting of DOE headquarters and field element representatives. Products of the DMCC include analysis of meteorological requirements embedded in DOE orders and guidance, site meteorological program peer reviews, and, as needed, customized technical assistance. Assist visits have been conducted at DOE/NV, WIPP, Pantex, and DOE/OR. A follow-up assist visit was also conducted at WIPP. Additional assist visits are in the planning stages and will be conducted over the next several years. The DMCC web page has been broadened and can be accessed at *www.sord.nv.doe.gov*.

Planned DMCC products include a DOE meteorological human resources directory, an updated meteorological requirement analysis, site meteorological program assist visit reports, and additional upgrades to the DMCC web page.